Intel® Celeron® Processor Thermal Design Guide

Application Note

December 2001

Order Number: 273421-003

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Revision History

Date	Revision	Description
Dec 2001	003	Added 850 MHz Celeron processor, updated 566 MHz and 733 MHz thermal design power numbers.
Dec 2000	002	Added 733 MHz Celeron processor, updated 566 MHz thermal design power number.
Aug 2000	001	First public release.

1.0 Introduction

This document provides thermal performance information for the Intel® Celeron® processor for applied computing. The Celeron processor is available for applied computing in a flip-chip pin grid array (FC-PGA) package with an integrated 128-Kbyte L2 cache at 566 MHz and 733 MHz (with a processor system bus speed of 66 MHz), and at 850 MHz (with a processor system bus speed of 100 MHz). The backside of the silicon die is exposed to enable more efficient heat transfer. The processor uses a PGA370 socket for installation into the motherboard. Details on the socket are available in the *370-Pin Socket (PGA370) Design Guidelines* (order number 244410).

The thermal solution focus is on heatsinks and fans to meet the performance requirements of the Celeron processor.

This application note:

- Introduces the specifications for the Celeron processor
- Defines target thermal parameters and clarifies terminology
- Identifies the concepts and airflow calculations used to design thermal solutions. Sample calculations are also provided.
- Identifies the z-height constraints of a thermal solution for single-slot and double-slot CompactPCI (CPCI) designs
- Discusses interface material and attachment methods for thermal solutions
- Provides a list of thermal solution vendors

This document provides supplemental thermal design information. Complete mechanical and thermal specifications are provided in the *Intel® Celeron® Processor up to 1.10 GHz* datasheet (order number 243658). Updates or changes to the specifications in the datasheet are listed in the *Intel® Celeron® Processor Specification Update* (order number 243748).

2.0 Importance of Thermal Management

The objective of thermal management is to ensure that the temperature of each component is maintained within specified functional limits. The functional limit is the temperature range within which the electrical circuits can be expected to meet their specified performance requirements. Operation outside the functional limit can degrade system performance and cause reliability problems.

The junction temperature is the surface temperature of the package at its hottest point, typically at the geographical center of the chip. Over time, temperatures exceeding the junction temperature limit can cause physical destruction or may result in irreversible changes in operating characteristics.

3.0 Intel® Celeron® Processor Thermal Specifications

This section provides needed data for designing a thermal solution. The Celeron processor uses FC-PGA packaging technology. To ensure functionality and reliability of the Celeron processor, the maximum device junction temperature ($T_{JUNCTION}$) must remain below the value provided in Table 1.

Table 1 provides the thermal design power dissipation and maximum temperatures for the Celeron processor for the PGA370 socket. Systems should be designed for the highest possible processor power, even if a processor with a lower thermal dissipation is planned. A thermal solution should be designed to ensure the junction temperature never exceeds these specifications.

Table 1. Intel® Celeron® Processor Power Dissipation and Junction Temperature

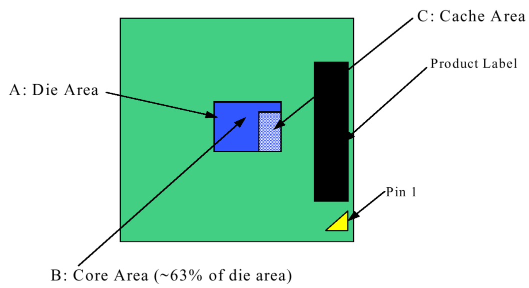
Celeron® Processor	Processor Core Frequency (MHz)	L2 Cache Size (Kbytes)	Thermal Design Power[1, 2] (W)	Power Density[3] (W/ cm^2)	Maximum $T_{JUNCTION}$ (°C)	$T_{JUNCTION}$ Offset[4, 5] (°C)
566 MHz	566	128	19.2[6, 7]	29.8[6]	90	2.6
733 MHz	733	128	22.8	35.5	80	2.8
850 MHz	850	128	25.7	40.0	80	3.3

NOTES:

1. Thermal Design Power (TDP) represents the maximum amount of power the thermal solution is required to dissipate. The thermal solution should be designed to dissipate the TDP power without exceeding the maximum $T_{JUNCTION}$ specification.
2. Note that the TDP specifications are thermal design requirements only and do not reflect voltage regulation or power delivery specification changes.
3. Power density is the maximum power the processor die can dissipate (i.e., processor power) divided by the die area over which the power is generated. Power for this processor is generated in the core area shown in Figure 1.
4. $T_{JUNCTIONOFFSET}$ is the worst-case difference between the thermal reading from the on-die thermal diode and the hottest location on the processor's core.
5. $T_{JUNCTIONOFFSET}$ values do not include any thermal diode kit measurement error. Diode kit measurement error must be added to the $T_{JUNCTIONOFFSET}$ value from this table. Intel has characterized the use of the Analog Devices AD1021* diode measurement kit and found its measurement error to be 1° C.
6. The Thermal Design Power (TDP) for Celeron processors in production has been redefined. The updated TDP values are based on device characterization and do not reflect any silicon design changes to lower processor power consumption. The TDP values represent the thermal design point required to cool Celeron processors in the platform environment while executing thermal validation type software.
7. For processors with CPUID of 0683H, the TDP number is 11.9 W.

Figure 1 is a block diagram of the Celeron processor die layout. The layout differentiates the processor core from the cache die area. In effect, the thermal design power identified in the figure is dissipated entirely from the processor core area. Thermal solution designs should compensate for this smaller heat flux area and not assume that the power is uniformly distributed across the entire die area.

Figure 1. Processor Functional Die Layout



3.1 Thermal Diode

The Celeron processor for the PGA370 socket incorporates an on-die diode that may be used to monitor the die temperature (junction temperature). A thermal sensor located on the motherboard, or a stand-alone measurement kit, may monitor the die temperature of the processor for thermal management or instrumentation purposes. Table 2 and Table 3 provide the diode parameter and interface specifications.

Note: The reading of the thermal sensor connected to the thermal diode will not necessarily reflect the temperature of the hottest location on the die. This is due to inaccuracies in the thermal sensor, on-die temperature gradients between the location of the thermal diode and the hottest location on the die at a given point in time, and time based variations in the die temperature measurement. Time based variations can occur when the sampling rate of the thermal diode (by the thermal sensor) is slower than the rate at which the $T_{JUNCTION}$ temperature can change.

Table 2. Thermal Diode Parameters

Symbol	Parameter	Min	Typ	Max	Unit	Notes
I_{FW}	Forward Bias Current	5		300	µA	1
n	Diode Ideality Factor	1.0057	1.0080	1.0125		2, 3, 4

NOTES:
1. Intel does not support or recommend operation of the thermal diode under reverse bias.
2. Characterized at 100° C with a forward bias current of 5 - 300 µA.
3. The ideality factor, n, represents the deviation from ideal diode behavior as exemplified by the diode equation:

$$I_{FW} = I_S \cdot \left(e^{qV_D/nkT} - 1\right)$$

   where I_S = saturation current, q = electronic charge, V_D = voltage across the diode, k = Boltzmann Constant, and T = absolute temperature (Kelvin).
4. Not 100% tested. Specified by design characterization.

Table 3. Thermal Diode Interface

Pin Name	PGA370 Socket pin #	Pin Description
THERMDP	AL31	diode anode (p_junction)
THERMDN	AL29	diode cathode (n_junction)

4.0 Thermal Characterization Data

Thermal solutions vendors have developed reference designs for the Celeron processor. Refer to Table 8, “Vendor List” on page 18 for a list of vendors for each type of solution.

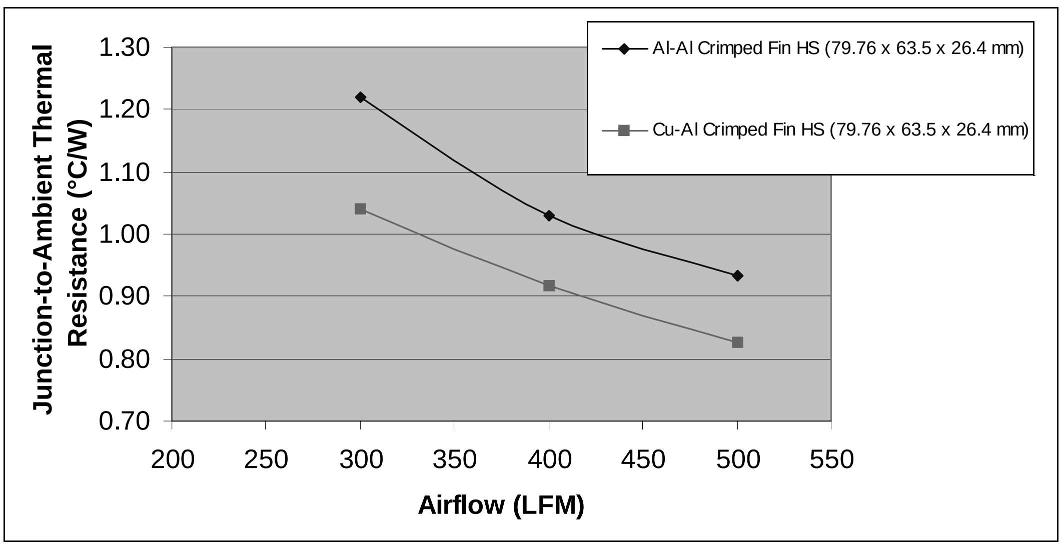
The thermal characterization data described in Table 4 illustrates that a thermal solution may be needed depending on the system’s operating ambient temperature and the system airflow that can be provided. The size of the heatsink and the amount of airflow are interrelated and can be optimized for a given system. In a typical system, heatsink size is limited by board layout, spacing, and component placement. Airflow is limited by the size and number of system fans and their placement in relation to the components and the airflow channels. Acoustic noise and life-expectancy constraints may also limit the size or types of fans used in the system.

Note: The inclusion of these reference designs by third-party thermal solution vendors should not be considered a recommendation or product endorsement by Intel Corporation.

Table 4. Celeron® Processor Characterization Data

Heatsink	Dimensions (LxWxH in mm)	θ_{ca} or θ_{ja} (°C/W) vs. Airflow (LFM)		
		300	400	500
Fitel Cu/Al Crimped Fin	79.76 X 63.5 X 26.4	1.04	0.918	0.825
Fitel Al/Al Crimped Fin	79.76 X 63.5 X 26.4	1.22	1.03	0.933

Figure 2. Celeron® Processor Thermal Resistance vs. Airflow



5.0 Determining Thermal Solution Design Parameters

5.1 Measuring Ambient Temperature

Ambient temperature (T_A) is the temperature of the undistributed air surrounding the component. Ambient temperature is usually measured at a specified distance from the component. In a system environment, ambient temperature is the temperature of the air upstream to the component and in its close vicinity. In a typical laboratory test environment, the ambient temperature for passive solutions is measured one hydro-dynamic diameter (one hydro-dynamic diameter is typically the length of the heatsink) upstream from the component to represent the ambient temperature with air flowing past the system. When natural convection is used in a system, the ambient temperature is measured directly underneath the board near the component. In an active cooling system, the ambient temperature is the inlet air to the active cooling device.

5.2 Measuring Junction Temperature

The Celeron processor for the PGA370 socket incorporates an on-die diode that may be used to monitor the die temperature (junction temperature). See "Thermal Diode" on page 7.

Warning: Do not attempt to measure the junction temperature by attaching a thermocouple to the die. This process is mechanically difficult and will not result in correct temperature readings. Attaching a thermocouple to the die may cause the die to crack and invalidates any warranty that may exist on the device.

5.3 Calculating Junction-to-Ambient Thermal Resistance

The junction-to-ambient thermal resistance determines the performance of the thermal solution and can be calculated using the following equation:

Equation 1. $$\theta_{JA} = (T_{JUNCTION} - T_A)/P$$

where:

θ_{JA} = junction-to-ambient thermal resistance (°C/W)
T_A = ambient temperature (°C)
$T_{JUNCTION}$ (= $T_{DIODE} + T_{JUNCTIONOFFSET}$) = junction temperature (°C)
P = device power dissipation (Watts)

The lower the thermal resistance between the junction and the ambient air, the more efficient the thermal solution will be.

The thermal resistance values depend on the heatsink material, thermal conductivity, thermal interface material, and geometry of the thermal cooling solution and airflow rates.

5.4 Estimating Required Airflow

Using TDP conditions at 566 MHz:

- The junction temperature at the processor die surface is 90° C
- The ambient temperature is 50° C
- The TDP max power dissipated by the 566 MHz Celeron processor is 19.2 W
- The junction-to-ambient thermal resistance (θ_{JA}, calculated using Equation 1 above) is 2.08° C/W

Knowing the θ_{JA} value allows the system designer to estimate the airflow required to keep the junction temperature at 90° C. The heatsink solutions would require about 300 LFM of airflow, depending on the thermal solution chosen.

Note: For Celeron processors with a CPUID of 0683h, the TDP number is 11.9 W, and the θ_{JA} is 3.36. The heatsink solutions require less than 300 LFM of airflow, depending on the thermal solution chosen.

Using TDP conditions at 733 MHz:

- The junction temperature at the processor die surface is 80° C
- The ambient temperature is 50° C
- The TDP max power dissipated by the 733 MHz Celeron processor is 22.8 W
- The junction-to-ambient thermal resistance (θ_{JA}, calculated using Equation 1 above) is 1.31° C/W

The heatsink solutions would require about 300 LFM of airflow, depending on the thermal solution chosen.

Using TDP conditions at 850 MHz:

- The junction temperature at the processor die surface is 80° C
- The ambient temperature is 50° C
- The TDP max power dissipated by the 850 MHz Celeron processor is 25.7 W
- The junction-to-ambient thermal resistance (θ_{JA}, calculated using Equation 1 above) is 1.17° C/W

The heatsink solutions would require about 300-400 LFM of airflow, depending on the thermal solution chosen.

5.5 Measuring Airflow

The airflow, or air velocity flowing across the components, can be measured using a portable air velocity meter (anemometer). The meter contains two temperature sensing elements. One element is used to track the air stream temperature and the second element is heated by an electrical current to maintain a constant temperature above the air stream temperature. As the air stream takes heat energy away from the heated element, more current is required to maintain the temperature

differential. The required electrical current is proportional to the air mass velocity displayed on the meter. This meter is available from Kurz Instruments. Refer to Table 8, “Vendor List” on page 18 for vendor information.

6.0 Thermal Solution Design Considerations

6.1 CompactPCI Component Height Requirements

The heatsink and fan solutions were designed to meet double-slot CompactPCI (CPCI) z-height constraints. Standard heatsinks or fans may be used for designs that do not need to meet the CPCI requirement. For the Celeron processor in FC-PGA, the z-height allowed for the single-slot CPCI heatsink thermal solution is 13.70 mm - 2.08 mm (FC-PGA) - 5.71 mm (Socket 370 height) = 5.91 mm (see Figure 3). For a double-slot CPCI heatsink thermal solution, the maximum z-height allowed is 26.2 mm (see Figure 4).

Refer to Table 8, “Vendor List” on page 18 for information on obtaining CompactPCI Specification.

Figure 3. Single-Slot CompactPCI Z-Height Specification

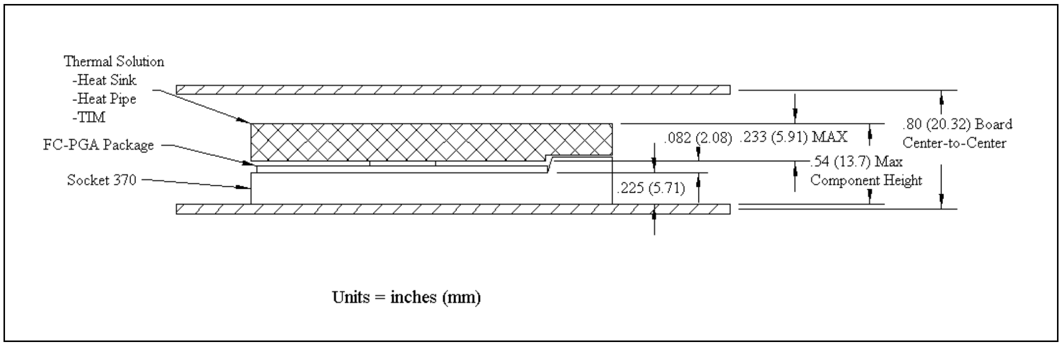
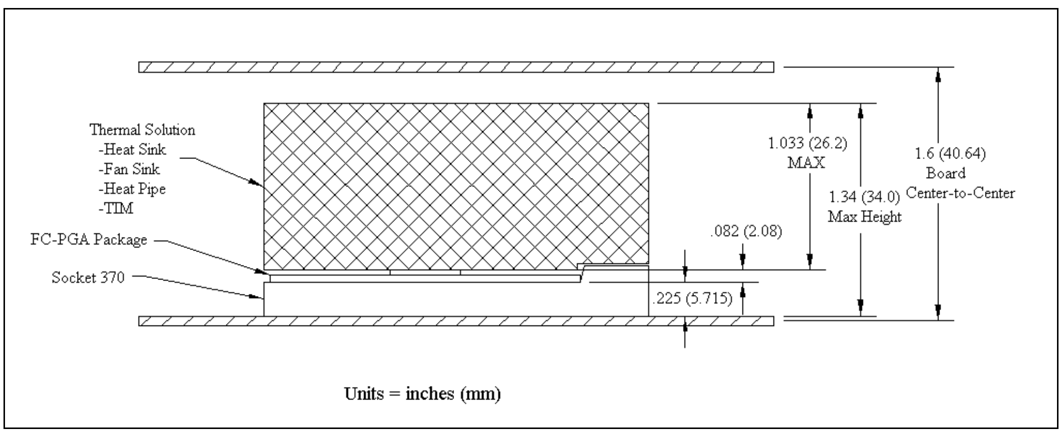


Figure 4. Double-Slot CompactPCI Z-Height Specification



6.2 Heatsink Solutions

6.2.1 Theory of Heatsink Operation

A heatsink is simply a metal surface with pins or fins rising up off the surface. Heatsinks are used to cool electronic devices by expanding the surface area of the part to which it is attached, increasing the amount of heat that can be cooled by the ambient air. A main characteristic of heatsinks is thermal resistance (θ), measured in °C/W. For example, if a component has a heatsink with a thermal resistance $\theta = 2°$ C/W, then for every Watt of heat it dissipates its temperature increases by 2° C. The larger the heatsink, the more surface area it has, and the better its thermal resistance.

6.2.2 Considerations for Implementing a Heatsink Thermal Solution

The following points should be considered when evaluating heatsink thermal solutions:

- **Cost.** Heatsink solutions typically are cheaper than the fan solutions. Extruded heatsinks typically cost less than corrugated, folded or bonded heatsinks.
- **Flexibility in x, y and z dimensions.** Based on the amount of airflow available in the system, a design may require a larger heatsink to dissipate a specified amount of heat. System designers may need to be flexible in at least one or two dimensions.
- **System airflow.** It is desirable to have some system airflow to allow heat to be removed from the heatsink.

Note: High fin density thermal solutions are only efficient if the area approaching and surrounding the heat sink is ducted. In addition, high fin density solutions will have higher airflow pressure drop through the heat sink; therefore, higher performance fans are often required. High fin heatsink solutions include corrugated, bonded fin and skived heatsink technology.

- **Extruded vs. Corrugated (Folded Fin).** An extruded heatsink has a lower cost but the folded fin heatsink typically provides better performance because of the extra surface area of the fins. Folded fin heatsinks are typically recommended for systems with minimal system airflow.
- **Extruded vs. Bonded Fin.** Extruded heatsinks fin height to fin spacing ratios are typically greater than 6:1 but less than 10:1. A bonded fin offers fin ratios greater than 30:1. Bonded fins expose more surface area to the cooling air, which transfers more heat away from the electronics.
- **Extruded vs. Skived.** Skive technology represents a process of shaping materials to produce lightweight, “high-fin-density” thermal solutions at high-volume with relatively low-costs as compared to performance-comparable high-fin density thermal technologies. In general, high-fin-density technologies such as skive, provide optimal thermal performance when coupled with by-pass air control features such as a shroud or system duct. Skived heatsinks can be made with fin pitch as narrow as 1.5 mm and fin thickness of 0.5 mm or thinner. Because skiving is a mechanical process with minimal temperature increase, the joint between fin and base is continuous aluminum. This property is shared with extrusions but not corrugated or bonded fin methods. Fin heights to 50 mm and aspect ratios to 25:1 are possible.

6.3 Fan Solutions

Passive-active fan heatsink solutions provide airflow and require little or no system airflow. Active fan heatsink solutions incorporate a fan that is attached to the solution.

For designs with no height restrictions, an active fan heatsink solution similar to that used for Intel boxed processors is recommended. The specifications for this solution are provided in the *Intel® Celeron® Processor up to 1.10 GHz* datasheet (order number 243658).

6.3.1 Theory of Fan Operation

The typical fan involves a motor and a propeller. The motor can be either an AC induction motor or a brushless DC motor. The air flow that a fan produces blows parallel to the fan's blade axis. These fans can be made to blow a significant amount of air. Fans can be:

- Used alone to ventilate cool intake air through the processor (pushing warm air out)
- Used in passive thermal solutions to blow hot air off of heatsinks
- Assembled with a passive thermal solution to blow hot air off the component heatsink.

6.3.2 Considerations for Implementing a Fan Thermal Solution

The following points should be considered when evaluating fan thermal solutions:

- **Performance at a moderate cost.** Fan solutions typically cost more than heatsink solutions.
- **System airflow.** When there is no system airflow, a dedicated fan attached above the component provides an excellent source of airflow, which can ensure prompt removal of heat from the heat source.
- **Flexibility in x, y or z dimensions.** The size of the required fan solution can vary according to the amount of heat that must be dissipated, the availability of system airflow, and other factors. To achieve certain thermal requirements, a system designer may need to be flexible with one or more dimensions of the design.
- **Reliability.** Fans are reliable and typically have a life of 100,000 hours depending on the fan design and the manufacturer's standards.
- **Recirculation.** The customer must ensure that the heated system air does not re-enter the fan.

6.4 Interface Material

Air ranks low in terms of thermal conductivity, and if trapped between thermal joints, reduces the junction-to-sink thermal resistance and the overall thermal resistance of the system. Thermal interface materials address this problem by providing a buffer between mating surfaces to increase actual points of contact between the junction and the sink.

Thermal interface material must be applied between the processor die and the heat sink to ensure thermal conduction. Thermal interface material also serves as a mechanical load element during mechanical stress testing (i.e., mechanical shock). Many thermal interface materials can be pre-applied to the heat sink base prior to shipment from the heat sink supplier and allow direct heat sink attach, without the need for a separate thermal interface material dispense or attach process in the final assembly factory.

Caution: Do not attempt to make direct contact to the die without using an interface material. Concentrated forces applied directly to the die surface will crack the silicon and cause the device to be non-functional.

The optimal material to use as the interface material between the silicon die surface and the heatsink must be determined for each application. Procedures for storage, handling, application of material, and removal for rework purposes are available from the vendor. Follow these procedures to ensure performance and reliability, and to avoid silicon die cracking or delamination issues.

The selection of the optimum thermal interface material between the device and heat sink must take into consideration the thermal performance, cost, ease of use, installation pressures, and long term stability. The following factors should be considered when selecting the interface material:

- Bulk thermal conductivity of the material: Materials with high thermal conductivity (low thermal resistance) are required. Determination of the bulk thermal conductivity of a material is governed by ASTM E 1530.
- Wetting/filling property of the material: The contact resistance of the interface contributes significantly to the overall interface resistance. Soft materials such as grease and low-durometer elastomers tend to deform readily to fill the contours of the die surface and heatsink base surface.
- Integrity of the material: The material must maintain its physical properties throughout the life of the product. Some materials are more sensitive than others to extended exposure to high-temperature or high-humidity environments. Accelerated life testing should be conducted to ensure that the thermal resistivity remains below the target value from the die to the thermal solution for the expected life of the product.
- Attach/Removal Process: Some thermal interface materials have high viscous and adhesive properties at room temperature and may transfer high tensile stresses directly to the processor die as the thermal solution is pulled away from the processor motherboard. Heat may have to be applied to the thermal solution and interface material prior to disassembly to “soften” the material for removal. If a pre-applied thermal interface material is specified, it may have a protective application tape. This tape must be removed prior to heat sink attach.
- Size and Position: All thermal interface materials must be sized and positioned on the heat sink base in a way that ensures the entire processor die area is covered. It will be important to compensate for heat sink-to-processor attach positional alignment when selecting the proper thermal interface material size.

Typical interface materials are greases, phase change materials, and elastomers. Grease may not be an ideal thermal interface material in this case due to its propensity to being squeezed out of the thermal gap by the thermal solution compression load. The resulting die-to-thermal solution contact may result in damage to the fragile silicon die.

6.4.1 Phase Change Materials

Phase change materials, at typical processor operating temperatures, behave very much like grease and flow to relieve any residual stresses and to fill the thermal gap, resulting in negligible interface pressure on the die. At room temperature, these materials are in a pliable, clay-like state that allows them to be pre-formed and placed onto the thermal solution in the same way as elastomers. The thermal solution should be a die-reference design that applies continuous pressure to the interface material. The phase change material may be squeezed out of the thermal gap and needs to be validated before using the material.

Caution: Phase change thermal interface materials are a class of material often selected due to their ease of use. In an evaluation of the mechanical behavior of thermal interface materials, Intel has determined that phase change materials which have an epoxy element can induce processor damage during heat sink removal. The epoxy materials used in some types of thermal interface materials do not cross-link, resulting in a polar compound. This polar compound is attracted to the polar oxide on the die and forms a strong bond between the heat sink base and the processor silicon surface, making the two surfaces extremely difficult to separate after the thermal interface material has cured. The force required can lead to processor damage; this damage may not always be visible. It may be important to consult with the thermal interface material supplier to determine its cross-linking characteristics.

6.4.2 Elastomeric Materials

Thermal elastomers provide an ideal interface material to complement the die-reference design requirement. The elastomer can be pre-cut by the supplier to adequately cover the die (a 1 mm overhang should be allowed for) and resist expansion ("pump-out") under compression. In general, better thermal performance will be obtained with the thinnest elastomer possible. The appropriate elastomer type and thickness must be selected to ensure the elastomer is always within the optimal compression range (typically greater than 207 kPa or 30 psi) so that the elastomer exerts no more than 689 kPa (100 psi) on the processor die surface during compression.

6.4.2.1 Thermal Grease

Thermal grease forms a conductive film between the junction and the sink that enhances heat transfers. Because microscopic air voids exist on solid surfaces regardless of mechanical precision, thermal grease fills these gaps with thermally conductive substances. This ensures maximum contact between the junction and sink and reduces the temperature greatly for better thermal performance.

6.4.2.2 Thermal Tapes and Adhesives

Thermal tapes and adhesives are flexible and conform to the gaps on the surfaces under initial applied pressure. Although they generally provide lower conductivity, thermal adhesives do not require mechanical fasteners and are simple to mount without the mess of a grease or compound.

Warning: Intel discourages the use of Thermal Tapes and Adhesives for the FC-PGA package.

6.4.2.3 Thermal Compound

Thermal compounds behave much like grease, since they melt during operation to permanently smooth surface irregularities. They are often injected with ceramic fillers and/or other thermally conductive compounds for improved performance. Application involves less mess than grease, and the material will not dry out.

6.4.2.4 Thermal Foils

Thermal foils integrate the advantages of thermal compounds and thermal tape. They fill voids in junction and sink surfaces, provide electrical isolation without completely compromising thermal conductivity, and are easily applied.

Warning: Intel discourages the use of Thermal Foils for the FC-PGA package.

6.4.3 Choosing an Interface Material

Available interface materials include:

- Chomerics XTS454* Low Thermal Resistance Pads - Phase Change Material

Table 5. Chomerics XTS454* Phase Change Material Properties

Property	XTS454* Specification
Carrier:	None
Specific Gravity:	1.1
Thickness:	0.14 mm
Phase Change Temperature:	45° C
Thermal Impedance (at 50° C, 50 psi):	0.04 °C-in^2/W
Thermal Conductivity (50 psi):	0.6 W/m-K
Volume Resistivity:	1 x 1015 Ω-cm

- Shin-Etsu Chemical Co., Ltd. G-749* Thermal Interface Material

Table 6. Shin-Etsu G-749* Thermal Interface Material

Property	G-749
Viscosity	3000 Poise Avg.
Appearance	Gray
Bleed (150° C/24 hr)	< 0.01%
Volatile Content	< 0.05%
Specific Gravity	2.73
Thermal Conductivity	2.9 W/m-°K

Refer to Table 8, “Vendor List” on page 18 for vendor information.

Note: Mention of specific brand-name interface materials should not be considered a recommendation or product endorsement by Intel Corporation.

6.5 Attach Methods

The heatsink attachment mechanism secures the heatsink to the board, provides adequate pressure to the heatsink for optimum thermal performance, and protects the backside of the die surface. The attachment mechanism should not interfere with the thermal ability of the package or inhibit the performance of the processor in the application.

The FC-PGA thermal solution should be attached to the PGA370 socket using a high-force, mechanical lever heatsink attach clip. The attach clip should be designed to meet a board level, 30-50 G trapezoidal, 11-ms duration, 170 in./s minimum velocity change shock. The mechanical lever clip should be designed to provide a tighter thermal bond-line than traditional metal clips and better thermal conductivity between the microprocessor, thermal interface, and heatsink. Refer to Table 8, “Vendor List” on page 18 for information on attach clip suppliers.

The thermal solution attachment should provide the following:

- Compression of the interface material: 30-60 psi (206-413 kPa); max pressure 100 psi (689 kPa).
- Flexibility to absorb die height variance.
- Support to the motherboard to prevent board warpage.

7.0 Related Documents

These documents are available for download from Intel's World Wide Web site at http://developer.intel.com.

Table 7. Related Documents

Document	Order Number
Intel® Celeron® Processor up to 1.10 GHz datasheet	243658
Intel® Celeron® Processor Specification Update	243748
Intel® 440BX AGPset/PGA370 Scalable Performance Board Design Guide	273296
P6 Family of Processors - Hardware Developer's Manual	244001
Intel Packaging Handbook	240800
370-Pin Socket (PGA370) Design Guidelines	244410

8.0 Vendor List

Table 8 provides a vendor list as a service to our customers for reference only. The inclusion of this list should not be considered a recommendation or product endorsement by Intel Corporation.

Note: Additional vendors of the Intel-enabled thermal/mechanical solutions may exist. Please refer to the Intel developer's web page for an update on qualified third party sources for Celeron Processor support components.

http://developer.intel.com/design/celeron/components/index.htm

Table 8. Vendor List (Sheet 1 of 2)

HeatSink and Fan Vendors	
Fitel C/O Computer Memory Disk 2380 Qume Dr. Unit D San Jose, CA 95131 Phone: (408) 232-9300 FAX: (408) 232-9310 Email:katsumizushima@mindspring.com	
Interface Material Vendors	
Chomerics 77 Dragon Court Woburn, MA 01888-4014 Phone: (781) 939-4486 Fax: (781) 938-6131 Email: jkefeyan@parker.com Web site: http://www.chomerics.com	**Shin-Etsu MicroSi** 10028 South 51st Street Phoenix, Arizona 85044 Phone: (888) - MICROSI (642-7674) Fax: (480) 893-8637 Web site: http://www.microsi.com

Table 8. Vendor List (Sheet 2 of 2)

Clips	
ITW Fastex Distribution 195 Algonquin Rd Des Plaines, IL 60016-6197 Phone: (847) 299-2222 Fax: (847) 390-6183	**Thermshield** P.O. Box 1641 Laconia, NH 03246 Phone: (603) 524-3714 Contact Tom Garrity
Air Velocity Meter Supplier	
Kurz Instruments, Inc. 2411 Garden Road Monterey, CA 93940 Phone: (800) 424-7356 Fax: (831) 646-8901 Email: sales@kurz-instruments.com Web site: http://www.kurz-instruments.com	
Temperature Measurement Supplier	
Omega Engineering, Inc. One Omega Drive P.O. Box 4047 Stamford, CT 06907-0047 Phone: (800) 622-2378 Fax: (203) 359-7700 Email: temp@omega.com Web site: http://www.omega.com	
CompactPCI Specification	
Order from: PICMG* (PCI Industrial Computer Manufacturers Group) Web site: http://www.picmg.org/	